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ORIGINAL ARTICLE

Intraseptal vs. periodontal ligament anaesthesia for maxillary tooth extraction: quality of local anaesthesia and haemodynamic response

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Abstract There is no data concerning the use of the intraseptal anaesthesia (ISA) for single tooth extraction. The aims of this study were to compare the clinical efficacy and haemodynamic responses of the ISA with the periodontal ligament anaesthesia (PLA) for single tooth extraction. Thirty-five randomly selected healthy patients (ASA I) undergoing maxillary lateral incisors extraction entered the study. Onset of anaesthesia, the width of the anaesthetic field and duration of anaesthesia were recorded by pinprick testing. Intensity of anaesthesia was evaluated on a visual analogue scale. Haemodynamic parameters were recorded simultaneously at different time points after anaesthesia injection. The two techniques of local anaesthesia did not show statistically significant differences regarding the success rate and onset of anaesthesia, while the duration of the ISA on the buccal site was significantly longer in comparison with the PLA. The intensity of the achieved anaesthesia, estimated by the experienced pain during procedure, pointed out that pain was recorded in 24% of cases in the ISA group, and in 19% in the PLA group without significant differences. Postoperative pain was found to be smaller in the ISA group (70.9% of treated sites) than in the PLA group (81.3% of treated sites); however, this difference was not significant. Although the heart rate increased in both groups, there were no significant differences in the patients' haemodynamic response between the ISA and the PLA. The results of the present study indicate that both techniques are useful and suitable for the routine tooth extraction.

Keywords Intraseptal local anaesthesia · Periodontal ligament anaesthesia · Tooth extraction · Anaesthetic parameters · Haemodynamic parameters

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Introduction

Tooth extraction in the maxilla is routinely performed using the supraperiosteal infiltration anaesthesia. On rare occasions, alternative techniques such as periodontal ligament anaesthesia (PLA) is needed for obtaining an adequate local anaesthetic effect [1, 2].

PLA provides the effective pulpal, osseous and soft-tissue anaesthesia [3, 4]. It has been reported that the PLA accomplished with 2% lidocaine with epinephrine resulted in a 100% painless tooth extraction [5]. Miller et al. [6] also reported a high level of successful PLA (98.4%) for operative dental procedures. The additional benefit of the PLA may be the fact that it provides anaesthesia in a localized area without producing unpleasant numbness of the lip and muscles of facial expression [4]. However, teeth indicated for the extraction sometimes demonstrate infection or inflammation at the PLA-injection site. This fact can decrease the anaesthetic efficacy [2] and lighten the possible spread of infection from the injection site deeper into the alveolar bone [7]. Since the most used local anaesthetics in dentistry today contain epinephrine as a vasoconstrictor, there is also a possibility of epinephrine-induced systemic reaction after the PLA, manifested in changes of cardiovascular parameters [8, 9].

Similarly to the PLA-injection technique, ISA also provides the osseous and soft-tissue anaesthesia solely at the injection site (intraseptal area) [2, 10]. This technique is especially suitable for root scaling and periodontal surgery, as well as painless placing of gingival retraction cords or matrix bands in the reconstruction of endodontically treated teeth [7]. It has been reported that the ISA, when used in accordance with the guidelines recommended, can overcome inconveniences associated with the PLA, especially when the condition of the periodontal tissue do not favour the use of the PLA [2, 10]. There is no data concerning the use of the ISA for the single tooth extraction.

The aims of this study were to compare the clinical efficacy of the ISA and PLA for single tooth extraction in the maxilla when lidocaine with epinephrine was used, as well as to assess haemodynamic responses and possible changes of cardiovascular parameters.

Materials and methods

The study included 35 randomly selected healthy patients of ASA I physical status (16 male and 19 female), of average age 37.1±12.3 years (mean±SD), undergoing maxillary lateral incisors extraction. Patients who had dental treatment under local anaesthesia, or had taken any medication within the last 48 h were not included in the study, nor were patients with acute dental pain or swelling, or a history of allergy to anaesthetics and analgesics. All patients were informed of the aims of the study and signed a written consent. The study was approved by the Ethical Committee of the Faculty of Dentistry, University of Belgrade.

Five days prior to the injection, all patients received oral hygiene instructions and were asked to use 15 ml of 0.12% chlorhexidine mouthrinse solution twice a day for 30 s. Reasons for the use of chlorhexidine were: antimicrobial effect on periodontal disease, prevention of postextraction alveolar osteitis and reduction of the risk of postextraction bacteremia. Each patient had two appointments for extraction of both lateral incisors in a period of 2 weeks. The first tooth extraction, on the randomly assigned site, was done using the ISA, and the PLA was applied for the extraction of the opposite lateral incisor 2 weeks later. Indication for tooth extraction was based on clinical and radiographic examination and included several diagnoses: non-vital teeth with no possibility of endodontic treatment and restoration, or with the failure of endodontic treatment, fracture of roots and teeth with progressive periodontal disease. Teeth with any acute or chronic periradicular infection or purulent periodontal lesions were excluded from the study protocol because of possible postoperative complications, side-effects and discomforts. The same oral surgeon performed both techniques of anaesthesia and did all the extractions in the investigated groups. A topical anaesthetic was applied for a minimum of 2 min before the injection of any anaesthesia. Patients received no premedication or additional medication during the period of investigation.

Both investigated techniques of anaesthesia have already been described in detail [11]. The ISA was performed with 27-gauge short needle inserted in the intraligamental anaesthetic syringe (N'Traling® Intraligamental Anesthetic Syringe, Septodont, France). The intraligamental anaesthetic syringe was equipped with a leverage mechanism which enables it to develop the high injection pressure to overcome tissue resistance. One thorough squeeze of the trigger released one constant dose (0.2 ml) of anaesthetic over a period of 20 to 30 s. The site of needle insertion was about 2 mm above the tip of the interdental papilla with the 90° angulation of the needle to the surface of the papilla until contact with the bone (Fig. 1). Applying the same pressure to the syringe, the needle was pushed slightly deeper (approximately 1 mm) into the interdental septum, and 0.2 ml of local anaesthetic was deposited during 20 seconds to avoid leakage of anaesthetic solution. The PLA was also applied with 27-gauge short needle in the same type of syringe as for the ISA. The needle was inserted into the gingival sulcus of the treated tooth apically until resistance was met (Fig. 2), and 0.2 ml of anaesthetic solution during 20 s was deposited. For both procedures, 2% lidocaine with 1:100.000 epinephrine (Lignospan®, Septodont, France) was used, altogether, 0.8 ml of the solution per patient (0.2 ml at the buccal and the palatal side, mesially and distally of the tooth).

Onset of anaesthesia was recorded by pinprick testing every 15 s using a sharp 27-gauge sterile needle probing (MonoJect®, Dental Needle, Mansfield, USA). The pinprick test was done through the papilla, the attached gingiva and the oral mucosa on the buccal side of the tooth, and on

Fig. 1 Injection of ISA 2 mm above the tip of the interdental papilla until the contact with bone. Gingival bleaching as a result of anaesthetic injection

Fig. 2 Injection of PLA

the palatal mucosa at the point of palatal papilla and 1 cm toward the palate. Pinprick testing was always done directly until contact with the periosteum. Duration of anaesthesia was evaluated by pinprick testing after tooth extraction, every 20 min to the moment when patients noticed a blunt sensation, following which, tests were made every 10 min till the anaesthetic wares off. The width of the anaesthetic field, expressed in millimetres, was measured 5 min after the local anaesthetic injection by flexible ruler and pinprick testing. This parameter was also measured in four areas on the buccal side of the mesial and distal papilla, attached gingiva, muco-gingival junction, oral mucosa and in two areas at the palatal side (Fig. 3). The level of discomfort/pain during tooth extraction was evaluated on a visual analogue scale (VAS) graded from 0 (no pain) to 100 mm (unbearable pain). The anaesthesia would be considered unsuccessful, and the patient excluded from the study, if an additional injection had to be given due to severe pain during tooth extraction.

Systolic blood pressure (SP), diastolic blood pressure (DP), mean arterial pressure (MAP) and heart rate (HR) were recorded prior to anaesthesia, and 5, 10, 15 and 30 min after administering anaesthesia. Cardiovascular parameters were measured simultaneously with monitored ECG records (Datex-Engstrom AS/3, Helsinki, Finland) to register any ischemic conditions (ST-segment depression).

Postoperative pain was controlled with ibuprofen 400 mg tablets (Brufen®, Galenika, Belgrade, Serbia). The number of patients with pain was recorded, as well as their need for analgesic medication. The patients were followed for 5 days to record any undesired postoperative side-effect, such as bleeding, dry socket, swelling, infection or any other discomforts. The presence of persistent sensory dysfunction was evaluated 1 week after extraction. Patient's opinion was evaluated 24 h after extraction on a two-point scale (1) Satisfied. If I were to need another tooth extraction in the future, I would ask for the same anaesthesia technique; and (2) Not satisfied. If I were to need another tooth extraction in the future, I would ask for a different anaesthesia technique.

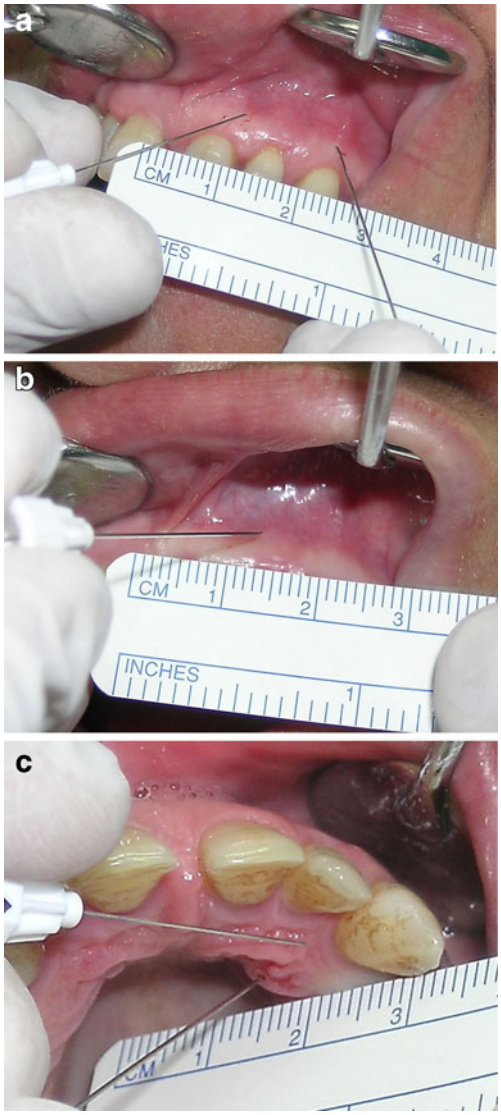

Fig. 3 The width of the anaesthetic field measured by the flexible ruler and pinprick testing **a** at the area of attached gingiva, **b** at the muco-gingival junction and **c** at the palatal side

The obtained results are presented as mean±SD and analyzed by an unpaired *t* test (two-tailed). Analysis was performed using Sigma Stat software (3.1 Sigma Stat Software Inc., Richmond, CA, USA). Comparisons were considered significant at $p<0.05$.

Results

Of 70 anaesthetized lateral incisors that were included in the study, seven were excluded from the evaluation (four from the ISA group and three from the PLA group) due to severe pain during extraction. At those sites, additional

maxillary infiltration anaesthesia was applied to complete tooth extraction. The success rates for the ISA and PLA were 88.6% and 91.4%, respectively, which was not statistically significant (Table 1). Patients were satisfied equally with both techniques of local anaesthesia. There were no significant differences between groups in terms of surgical parameters (Table 1).

The two techniques of local anaesthesia did not show statistically significant differences regarding the onset of anaesthesia, whereas the duration of the ISA on the buccal site was significantly longer in comparison with the PLA (Table 2).

An assessment of the intensity of anaesthesia, based on the patient's experience of pain during tooth extraction, pointed out that 24% of the patients in the ISA group felt pain, compared with 19% in the PLA group, which was not a notable difference. Moreover, there was no significant statistical difference between the two groups when intensity of pain was evaluated by VAS scale (Table 3).

The width of anaesthetic field achieved after the ISA- and the PLA-injection techniques was determined by pinprick testing in a similar manner, both labially and palatally. A difference between the two groups concerning this parameter was noticed at the level of oral mucosa, where the width of anaesthesia after the ISA, in the medio-lateral and marginal-superior direction, was significantly greater compared with the PLA (Table 4).

No complications or side-effects were recorded in the postoperative period. According to the patients' evaluation of analgesia, postoperative pain was found to be smaller in the ISA group (70.9% of treated sites) than in the PLA group (81.3% of treated sites); however, this difference was not significant (Table 5). Also, the percentage of patients taking first analgesic medication was not statistically different between the ISA group (68%) and the PLA group (77%). On the other hand, there was a significant difference between the groups concerning time of taking the first rescue dose of ibuprofen. Furthermore, the difference was significant for both, the number of patients and the moment of taking the second analgesic dose (Table 5).

Table 1 Anaesthetic procedure and surgical data of the investigated patients

Parameters	ISA	PLA
Duration of procedure (min)[a]	10.1±2.2	7.4±1.6
No. of anaesthetic techniques given	35	35
No. of teeth anaesthetized (successful events)	31/35	32/35
Satisfied/Unsatisfied with the anaesthetic effect	23/8	26/6

[a] Mean±SD

Table 2 Onset and duration of intraseptal (ISA) and periodontal ligament anaesthesia (PLA)

Technique	Anaesthetic parameters (mean±SD)			
	Onset (s)		Duration (min)	
	Buccal	Palatal	Buccal	Palatal
ISA	20±11	30±7	90±9*	60±11
PLA	30±6	20±7	70±6	55±7

*$p<0.05$ ISA vs PLA

Concerning the cardiovascular parameters in patients undergoing ISA and PLA, the analysis of the registered SP and MAP indicated a significant decrease in both groups 30 min after the administration of anaesthesia compared with basal values (values before the administration of anaesthesia). There were no significant statistical differences in SP, DP and MAP between the ISA and the PLA during the observation period (Fig. 4). On the other hand, HR measured 10, 15 and 30 min after the adimistration of anaesthesia significantly increased in both groups related to the basal values, which was not statistically significant between groups (Fig. 5). No changes of the ECG were recorded.

Discussion

The results of the present study indicate that both techniques, ISA and PLA, are useful and suitable for the routine tooth extraction. It has already been shown that ISA manifested a reliable local anaesthetic effect when used in periodontal surgery. Saadoun and Malamed [7] successfully performed flap curettage surgery, with or without osseous surgery, using ISA on a hundred patients with moderate or advanced periodontal disease—ISA appeared to be applicable in both maxillary and mandibular arches, with a success rate of 92% to 98%. In the present clinical study, ISA manifested similar efficacy as PLA for routine tooth extraction. Although the success rate of the PLA was slightly higher than that of the ISA, no significant differences were observed. Moreover, the intensity of the achieved anaesthesia for tooth extraction was satisfactory in both groups.

Table 3 Intensity of intraseptal (ISA) and periodontal ligament anaesthesia (PLA)

Technique (n)	Pain / No Pain	VAS / mm (mean ± SD)
ISA (31)	6/25	28±13
PLA (32)	5/27	21±7

Table 4 Width of the anaesthetic field for intraseptal (ISA) and periodontal ligament anaesthesia (PLA)

Parameters	Treatment (mean±SD)	
	ISA (mm)	PLA (mm)
Buccal side (*n*)	(31)	(32)
Papillae	Complete anaesthesia	Complete anaesthesia
Attached gingiva		
Medial-lateral	20.1±5.0	17.4±2.1
Muco-gingival junction		
Medial-lateral	18.6±3.2	16.6±4.4
Oral mucosa		
Medial-lateral	24.8±2.6*	13.2±4.3
Attached gingiva and oral mucosa		
Marginal-superior	22.9±3.2*	8.7±2.5
Palatal side (n)	(31)	(32)
Papillae	Complete anaesthesia	Complete anaesthesia
Palatal mucosa		
Medial-lateral	15.3±3.6	13.9±5.2
Marginal-superior	17.1±4.2	14.1±3.8

*$p<0.05$ ISA vs PLA

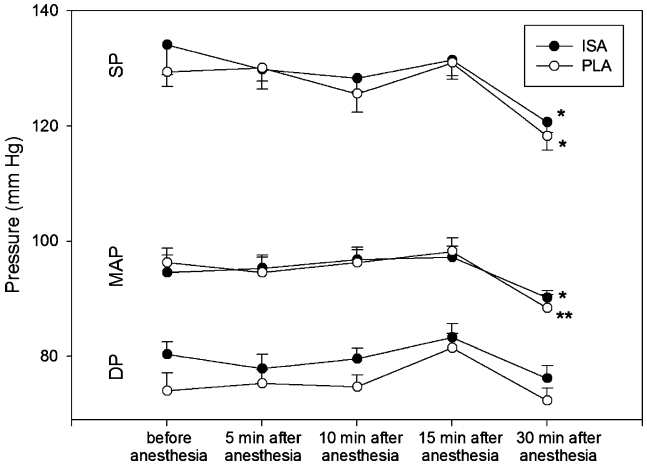

Fig. 4 Changes in systolic (*SP*), diastolic (*DP*) and mean arterial (*MAP*) pressure during intraseptal (*ISA*; *filled circle*) and periodontal ligament (*PLA*; *empty circle*) anaesthesia with lidocaine plus epinephrine. Each point represents mean±SD. *$p<0.05$, **$p<0.01$, compared with corresponding values before anaesthesia

Providing rapid onset of osseous and gingival anaesthesia, as well as suitable duration of complete tissue anaesthesia (60–90 min), ISA is effective for routine tooth extraction. This can be explained by the fact that a local anaesthetic can easily diffuse from the point of deposition through the marrow spaces toward root-apical and periodontal nerves [10]. Namely, the anaesthetic penetrates the perforations of the alveolar cortex at the site of application at the interdental septum (Fig. 6) and anaesthetizes soft tissue of the gingiva, alveolar bone, periodontium and tooth apical nerves, which is a prerequisite for adequate pain control during tooth extraction [2].

It is convenient that different techniques of local infiltration anaesthesia can be alternatively used in case of failure to achieve the required anaesthetic effect [11]. In the present study, four out of 35 ISA, and three out of 35 PLA failed to achieve the satisfactory local anaesthesia for tooth extraction. In all cases of failure, the additional supraperiosteal application of local anaesthetic provided the sufficient local anaesthetic effect. Moreover, based on previous studies, the PLA has already been recommended as an alternative technique in cases where initial supraperiosteal anaesthesia has failed [12]. A similar positive effect could also be expected from the ISA, which means that all these infiltration techniques for maxillary tooth extractions could be used as an alternative in cases of previous anaesthesia failure.

Postoperative discomfort, especially sensitivity of the anaesthetized tooth to biting, is usually attributed to the PLA [2]. Despite the fact that this study was concerned with the use of PLA and ISA techniques for tooth extraction, postextraction discomfort connected with healing of the extraction wound was not noteworthy and could not be attributed to the used anaesthesia techniques, although it has been documented that postextraction alveolar osteitis can occur after PLA [13]. However, it is interesting to note that postoperative pain and the need for

Table 5 Postoperative analgesia after tooth extraction under intraseptal anaesthesia (ISA) and periodontal ligament anaesthesia (PLA)

Treatment	Parameters (mean±SD)			
	Presence of pain Yes/no (*n*)	Time of first pain report/min	Time of first analgesic doses taken/min (*n*)	Time of second analgesic doses taken/min (*n*)
ISA	22/9 (31)	80±12	120±9* (15)	0* (0)*
PLA	26/6 (32)	55±15	70±13 (20)	342±46 (5)

*$p<0.05$ ISA vs PLA

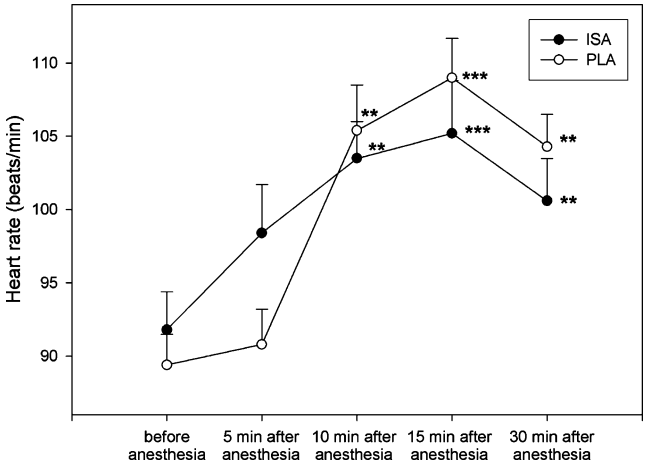

Fig. 5 Changes in heart rate (*HR*) during intraseptal (*ISA*; *filled circle*) and periodontal ligament (*PLA*; *empty circle*) anaesthesia with lidocaine plus epinephrine. Each point represents mean±SD. $^{**}p<0.01$, $^{***}p<0.001$ compared with corresponding values before anaesthesia

postoperative pain-relief medication in the first 24 h was considerable in both investigated groups, probably due to the increased pressure exerted during the application of both anaesthesia techniques.

It is known that resorption of local anaesthetic from the site of application when PLA or ISA are used is relatively rapid [2]. It could, consequently, lead to possible adverse effects due to rapid rise of local anaesthetic or epinephrine blood concentrations. However, results of the present study do not support this notion. In general, cardiovascular findings connected with the epinephrine-containing anaesthetic from the present study are in agreement with extensive experience in the safe use of this vasoconstrictor in dental practise [14]. Blood pressure changes were insignificant, with the exception of a moderate fall of systolic and mean arterial pressure seen at the end of the procedure, which may be related, at least in part, to the alleviation of the common stress-related activation of the autonomic system [15]. On the other hand, a significant rise of heart rate seen in the period 10–30 min after both ISA and PLA corresponds with the similar effect that we have observed after maxillary infiltration anaesthesia [16]. Notably, anaesthesia with lidocaine combined with epinephrine could result in a significant increase in heart rate with the use of a high-pressure syringe [17]—introduced under pressure, the anaesthetic and vasoconstrictor are inserted directly into the marrow and periodontal blood vessels [8, 18]. However, it is still unknown if the change of heart rate is related to the intraligamentary injection response or rather to the rapid deposition of the epinephrine-containing anaesthetic solution. It is known that epinephrine possesses a more than five times lower affinity for beta1 compared with the beta2 receptors [19], and an even lower affinity for the contraction-mediated alpha receptors [20]. Consequently, the dominant beta2 effect, which tends to decrease peripheral resistance, may have elicited compensatory baroreceptor reflexes after the ISA or PLA injections, and hence added to the heart stimulation effected by the beta1 receptor mechanism. Moreover, the minor population of beta2 receptors in the heart [19] may have been additionally activated by epinephrine escaped from the site of administration. However, the lack of in vivo occupancy data for distinct receptor subtypes after intraosseous application [2], requires further investigations in order to substantiate this assumption.

Fig. 6 Perforations of the maxillary alveolar cortex at the site of the anaesthetic application of the interdental septum

Beside the possible cardiovascular side effects, it is known that PLA is followed by a high incidence of bacteraemia as a result of injection through infected area of the gingival crevice [21, 22]. On the other hand, the study of Roberts et al. [23] showed that the modified intraligamental technique, a technique where the needle tip passes through the buccal alveolar mucosa 2–3 mm apical to the gingival margin avoiding direct contact with gingival crevice, caused significantly less bacteraemia than the conventional PLA. Although the purpose of this study was not to investigate the relationship between anaesthetic techniques and odontogenic bacteraemia, it is important to note that ISA would seem to have an advantage over the conventional PIA in the reduction of dental bacteraemia especially in the risk group of cardiovascular patients.

In conclusion, the present findings revealed that both techniques, the ISA and the PLA, are effective and safe for routine tooth extraction in healthy patients.

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Conflict of Interest The authors declare that they have no conflict of interest.

References

1. Blanton PL, Jeske AH (2003) Dental local anesthetics. Alternative delivery methods. JADA 134:228–234
2. Malamed SF (2004) Supplemental injection techniques. In: Malamed SF (ed) Handbook of local anesthesia, 5th edn. Mosby, St. Louis, pp 255–261
3. Berlin J, Nusstein J, Reader A, Beck M, Weaver J (2005) Efficacy of articaine and lidocaine in a primary intraligamentary injection administered with computer-controlled local anesthetic delivery system. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 99:361–366
4. Meechan JG (1992) Intraligamentary anaesthesia. Review. J Dent 20:325–332
5. Malamed SF (1982) The periodontal ligament (pdl) injection: an alternative to inferior alveolar nerve block. Oral Surg Oral Med Oral Pathol 53:117–121
6. Miller AG (1983) A clinical evaluation of the Ligmaject periodontal ligament injecton syringe. Dent Update 10:639–643
7. Saadoun AP, Malamed SF (1985) Intraseptal anesthesia in periodontal surgery. JADA 111:249–256
8. Nusstein J, Berli J, Reader A, Beck M, Weaver J (2004) Comparison of injection pain, heart rate increase, and postinjection pain or articaine and lidocaine in primary intraligamentary injection administered with a computer-controlled local anesthetic delivery system. Anesth Prog 51:126–133
9. Pashley DH (1986) Systemic effects of intraligamentar injection. J Endodon 12:501–504
10. Woodmansey K (2005) Intraseptal anesthesia: a review of a relevant injection technique. Gen Dent 53(6):418–420
11. Meechan JG (2002) Supplementary routes to local anaesthesia. Review. Int Endod J 35:885–896
12. Meechan JG, Ledvinka JIM (2001) Pulpal anaesthesia for mandibular central incisor teeth: a comparison of infiltration and intraligamentary injection. Int Endod J 35:629–634
13. Tsirlis AT, Iakovidis DP, Parissis NA (1992) Dry sockets: frequency of occurrence after intraligamentary anesthesia. Quintessence Int 23(8):575–577
14. Meral G, Tasar F, Sayin F, Saysel M, Kir S, Karabulut E (2005) Effects of lidocaine with and without epinephrine on plasma epinephrine concentrations and hemodynamic values during third molar surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 100:E25–E30
15. Goldstein DS (2003) Catecholamines and stress. Endocr Regul 37:69–80
16. Brkovic B, Gardasevic M, Roganovic J, Jovic N, Todorovic L, Stojic D (2008) Lidocaine+clonidine for maxillary infiltration anaesthesia: parameters of anaesthesia and vascular effects. Int J Oral Maxillofac Surg 37:149–155. doi:10.1016/j.ijom.2007.07.019
17. Cannell H, Kerwala C, Webster K, Whelpton R (1993) Are intraligamentary injections intravascular? Br Dent J 175:281–284
18. Kim S, Edwall L, Trowbridge H, Chien S (1984) Effects of local anesthesia on pulpal blood flow in dogs. J Dent Res 63(5):650–652
19. Hoffmann C, Leitz MR, Oberdorf-Maass S, Lohse MJ, Klotz KN (2004) Comparative pharmacology of human beta-adrenergic receptor subtypes-characterization of stably transfected receptors in CHO cells. Naunyn Schmiedebergs Arch Pharmacol 369:151–159
20. Hargreaves KM, Neidle EA (1998) Adrenergic drugs. In: Yagiela JA, Neidle EA, Dowd FJ (eds) Pharmacology and therapeutics for dentistry, 4th edn. Mosby, St. Louis, pp 85–100
21. Bender IB (1995) Post-treatment bacteremia. JADA 126(11):1474–1476
22. Roberts GJ, Simmions NB, Longhurst P (1992) Odontogenic bacteraemia and intraligamental analgesia. Br Dent J 173 (6):195
23. Roberts GJ, Simmions NB, Longhurst P, Hewitt BB (1998) Bacteraemia following local anaesthetic injection in children. Br Dent J 185(6):295–298